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Three-Dimensional Micro-CT of Vascular Tree and Bone Microarchitecture

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Beamline(s): X2B

Introduction: Four micro-CT scanning sessions were performed at NSLS on Beam X2B in the past year. We used the synchrotron micro-CT scanner for those specimens where CT gray scale linearly and spatial resolution better than 5 micrometers were necessary. Several disparate scientific studies used this capability to provide unique data about the 3D microarchitecture and structural composition.

Methods and Materials: Dr. Erik L. Ritman's specimens included emoblized pig myocardium with contrast medium in the coronary arteries. The coronary arteries were embolized with polymer microspheres of either 10, 30, 200 or 300 micrometers in diameter prior to euthanazia of the pig. Next, the arteries were injected with a radiopaque contrast agent prior to scanning. The voids in the microvascular filling were attributed to the perfusion territory of the embolized arteries. From this information we can compute the perfusion territory volume as a function of vascular diameter. This relationship provides insight into the metabolic demands of myocardium and how the coronary artery branching geometry responds to this.

Dr. Russell T. Turner's project involved scanning iliac crest biopsies obtained before and a year after start of treatment with a bone enhancing drug. The scans were performed at 10 micrometers resolution and at 17 keV. This permitted him to measure trabecular surface erosions (index of osteoclast cell erosion activity) and the several grey scales of the bone allowed him to assess the deposition of new bone as an index of osteoblast cell bone deposition activity. The analysis is incomplete but it is hoped it will shed light on the conventional analysis of bone microarchitecture which does not correlate well with the clinically observed reduction in bone fracture rate.

Dr. Lilach O. Lerman's project involves feeding pigs with a high cholesterol diet and then scanning pieces of their myocardium for quantitation of the microvascular structure and density. There clearly is an increase in microvascular branch numbers and density. It now remains to be seen whether this phenomenon is a reparative phenomenon or actually a cause of impaired microvascular structure.

Dr. Rebecca Chinery's project involves scanning the isolated colons of mice genetically predisposed to formation of colonic adenomas and ultimately cancers. Of particular interest is the increase in new vascularity that occurs in the early stages of the adenoma formation as well as the increase in the size of the native vessels that are in series with the new vascular growth. This latter, especially, is best observed with the 3D images generated with micro-CT.

Dr. J. Carlos Romero's project involved scanning kidneys of mice with a genetic predispostion to disruption of the microvasulature within the kidney. The kidney was shown to be characteristically changed in this condition and the functional implications of this structural change are being analyzed.

Dr. Virigina M. Miller's project involves the investigation of the possible role of nanobacteria in the pathological calcification in arterial walls and the kidney. Hence, we scanned rats' hearts and kidneys to find the calcifications and those regions could subsequently be histologically sampled for more detailed analysis.

Dr. Cornelia Weyand's project involves studying the new vascularation of joint synovial membranes in arthritis. Mice were used to host arthritic synovial membrane and this tissue's vascular system was injected with radiopaque contrast agent prior to scanning. It is clear that the new vessel growth is mainly capillaries and not larger vessels.

Conclusions: The image results are very encouraging. The actual analysis of these image data is still in process due to the huge amount of data involved in each (which are made up of 4 gigavoxels, 16 bits greyscale each).